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Architecture and morphology of coral reef sequences. Modeling and observations from uplifting islands of SE Sulawesi, Indonesia

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During the Late Neogene, sea level oscillations have profoundly shaped the morphology of the coastlines of intertropical zones, wherein relative sea level simultaneously controlled reef expansion and erosion of earlier reef bodies. In uplifted domains like SE Sulawesi, the sequences of fossil reefs display a variety of fossil morphologies. Similarly, the morphologies of the modern reefs are highly variable, including cliff notches, narrow fringing reefs, wide flat terraces, and barriers reefs. In this region, where uplift rates vary rapidly laterally, the entire set of morphologies is displayed within short distances. We developed a numerical model that predicts the architecture of fossil reefs sequences and apply it to observations from SE Sulawesi, accounting -amongst other parameters- for reef growth, coastal erosion, and uplift rates. The observations that we use to calibrate our models are mostly the morphology of both the onshore (dGPS and high-resolution Pleiades DEM) and offshore (sonar) coast, as well as U-Th radiometrically dated coral samples. Our method allows unravelling the spatial and temporal evolution of large domains on map view. Our analysis indicates that the architecture and morphology of uplifting coastlines is almost systematically polyphased (as attested by samples of different ages within a unique terrace), which assigns a primordial role to erosion, comparable to reef growth. Our models also reproduce the variety of modern morphologies, which are chiefly dictated by the uplift rates of the pre-existing morphology of the substratum, itself responding to the joint effects of reef building and subsequent erosion. In turn, we find that fossil and modern morphologies can be returned to uplift rates rather precisely, as the parametric window of each specific morphology is often narrow.